SUSTAINABLE NITROGEN FERTILIZATION STRATEGIES FOR NO-TILLAGE WHEAT

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SUMMARY

No-tillage wheat production has gained significant acreage across Virginia over the last 10 years. The recent high cost of nitrogen (N) fertilizer has prompted producers to look for additional ways to increase efficiencies in fertilizer management. The use of N injection equipment is currently being evaluated in no-tillage corn production and may also be useful to no-tillage wheat fertilization. This study has shown that further work is warranted with wheat to determine if N injection can lower the overall N application rates while still maintaining high wheat yields.

INTRODUCTION

Wheat is an important crop to Virginia producers as we annually produce 230,000 acres valued in excess of $71.5 million (USDA-NASS, 2008). A recent study indicated that worldwide N fertilizer efficiency in cereal crops averages 33%; meaning that 67% of applied fertilizer is not taken up by the small grain plants (Raun and Johnson, 1999). Nitrogen losses commonly occur by leaching, volatilization when using urea containing fertilizers, and assimilation by competing microbes in the soil system (Havlin et. al., 1999; Westfall et. al., 1996). Nitrogen losses from volatilization are aggravated in conservation tillage systems where large amounts of crop residue remain on the soil surface. Assuming the average Virginia winter wheat producer applies 120 pounds of N per acre in their Spring applications, Raun and Johnson's (1999) estimates mean that nearly 18.5 million pounds or $9.2 million of N fertilizer is lost to the environment per year in Virginia alone ($300/ton for 30% liquid urea-ammonium nitrate = $0.50 per pound of N; Crop Production Services, personal communication, June 2009). Exorbitant losses waste natural resources, pollute sensitive waterways, add to greenhouse gas emissions, and cause a decrease in fertilizer use efficiency that reduces farmers' profit margins.

Virginia small grain producers have higher fertilizer use efficiency than the world average, but technology exists to further increase our farmers' N efficiency. For instance, a recent study in Kansas indicated that different N placement methods on winter wheat increased plant N uptake (Kelly and Sweeney, 2007). In the Kansas study, broadcast N applications had the lowest N uptake (52 lbs N/acre); which is the standard fertilization practice in Virginia. Banding N increased uptake by 10% (57 lbs N/acre) while subsurface banding increased N uptake by nearly 30% (67 lbs N/acre). Reducing average spring wheat applications by 30% would save Virginia producers over $4.1 million and reduce N losses via environmental factors by 8.3 million pounds, annually. On-farm research trials with corn in Virginia have indicated that N rates may be cut 10-15% by injecting UAN solution two inches into the soil under the residue compared to surface dribble applications (Davis and Lewis, 2008). Kansas' climate and soil conditions vary

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significantly from Virginia’s climate and soil; however, we expect to see greater efficiency increases in Virginia than observed in Kansas since we have a greater chance of N being lost via volatilization and leaching in our high rainfall, warm, and sandy soil growing conditions (Hayden and Michaels, 2008).

MATERIALS AND METHODS

No-tillage wheat was planted following corn at two locations in Virginia. A sandy loam at the Virginia Tech Eastern Shore AREC (data not presented) and a loam soil in the Coastal Plains region of Virginia in Prince George County were selected. Different N application treatments were applied using an N applicator capable of applying surface and subsurface treatments. Treatments included surface-broadcast, surface-banded (15 and 30 inch bands), and subsurface-banded applications (15 and 30 inch bands) of urea-ammonium nitrate fertilizer (30% N) at four different N rates (40, 80, 120, and 160 lbs N/acre). Three no-fertilizer controls were included. Two of the no-fertilizer controls had the subsurface applicator ran across the plots (at 15 and 30 inch spacing) to test for plant damage from the no-tillage coulters. Nitrogen treatments were made in the spring with 50% of the N applied at Zadoks' growth stage 25 and the remaining N applied at Zadoks’ growth stage 30. All other production practices were made according to Virginia Cooperative Extension recommendations for no-tillage wheat (Thomason et. al., 2004). Wheat samples from 7 square feet were taken from each plot and analyzed for aerial dry matter production and N concentration at early heading (data not presented). From this data, plant N uptake and N fertilizer efficiency will be calculated. A plot combine was used to harvest wheat plots and yield calculated after correcting harvest weights for moisture. Economic analysis will be conducted to predict farmer profit increases due to increased yields and reduced fertilizer rate recommendations that result from increased N fertilizer efficiency.

RESULTS AND DISCUSSION

The data presented represent the 2009 results from the Brandon Plantation site in Prince George County, VA. The 2009 season produced average wheat yields for the region. Wheat yields ranged from 43.8 bu/A to 75.6 bu/A. There was not a significant interaction between N rates and fertilizer application method on grain yields therefore the data was averaged across N rates or application method to determine main factor values.

All N rates significantly increased grain yields over the no N control plots (Table 1) when averaged across application method. Grain yields did not plateau or decline as expected at high N rates, but linearly increased up to the 160 lb/acre N rate yielding 67.3 bu/A. The 0 to 120 lb/A N rates were not significantly different in grain test weight but the 160 lb/A had the lowest test weight at 59.7 lbs/bushel. None of the test weight values were low enough to cause a discount at market. There was a significant difference in moisture concentrations (11.4 to 11.9%); however, there is no practical importance as no discount would be incurred at market. Increasing N rates did have a significant impact on lodging percentage. The 0, 40, 80, and 120 lb N/A rates were not significantly different from each other in lodging percentage ranging from 18 to 29 percent. The 160 lb N/A rate had a 43% lodging rate. This would significantly affect the harvest speed in a commercial farming operation. The lodging rate of the control plot at 18% would also be unacceptable to wheat farmers. It should be noted that deer damage is suspected to have caused some lodging in the plots. Deer scat was observed in several plots on top of lodged wheat. The test plot was also the last standing wheat in this particular field so it was attractive to deer. Wheat biomass also linearly increased with increasing N rates and ranged from 7015 lbs/A to 8489 lbs/A.

Nitrogen application methods significantly impacted grain yields (Table 2) when averaged across N rates. The lowest yielding plot was the 15 inch injected treatment at 53.8 bu/A. The highest yielding treatment was the 15 inch surface band application at 70 bu/A. The broadcast, 30 inch surface band, and 30 inch injected were not significantly different in yield at 62.3, 62.4, and 62.5 bu/A, respectively. We suspect that the 15 inch injected treatment was damaged by driving over the plots 2 times with the tractor to create the 15 inch spacing with a 30 inch spacing applicator. The 15 inch surface band did not receive any tractor damage at GS 30 since it was applied with a CO_2 backpack sprayer. There was a significant difference in grain test weight with the 15 inch injection being highest at 60.8 lbs/bu with other treatments being similar (60 to 60.2 lbs/bu). There was a difference in moisture with the injected treatments having higher water concentrations (11.9 and 12%) compared to the broadcast and surface band treatments (11.4 to 11.6%). However, all moisture concentrations were acceptable for marketing wheat with no discount. It is likely the damage caused by injection caused late tillers to predominate therefore they were not as dry at harvest. Lodging percentage was the highest with the broadcast treatment at 42% of the plot. The 15 and 30 inch surface band treatments were similar at 31% and 28%, respectively. The 15 and 30 inch injected treatments had the lowest lodging levels at 14% and 17%, respectively. The lowest biomass levels were obtained with the 15 inch injected treatment at 7256 lbs/A. The broadcast, 15 inch surface band, and 30 inch surface band treatments were not significantly different in biomass yield. The 30 inch injected treatment yielded 7865 lbs biomass per acre but was not different from the highest and lowest yielding plots. It was evident at early headed that the 30 inch injected treatment had the most variability in growth within the plot. The N bands were readily visible with pale green plants at the center between each band.

CONCLUSION

Grain yield data suggest that spring N rates from 80-120 lbs per acre are adequate for good wheat yields. This is the range currently recommended by Virginia Cooperative Extension guidelines based on tiller counts and plant tissue sampling. The idea of banding N deserves more study in Virginia. The 15 inch surface band produced high yields and had less lodging than broadcast treatments. Banding wheat N holds promise as a method to gain more yield with the same N inputs currently used. The 15 inch surface band would require slight modifications to our current application equipment compared to obtaining a fertilizer injection applicator. This study will be repeated in 2010 to further explore N banding potential.

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Table 1. Nitrogen (N) rate main effect on grain yield, test weight, moisture, lodging, and above ground biomass on a loam soil in Prince George County, VA. All means are averaged over N application method.

N Rate	Yield	Test Weight	Moisture	Lodging	Biomass
	---bu/A---	---lbs/bu---	--------------%	--------------	---lbs/A---
0	56.0	60.3	11.9	18	7015
40	61.0	60.7	11.8	20	7715
80	62.1	60.2	11.6	29	8333
120	64.5	60.3	11.8	23	8499
160	67.3	59.7	11.4	43	8489
$LSD_{0.10}$	3.8	0.5	0.2	12	670

Table 2. Nitrogen application method main effect on grain yield, test weight, moisture, lodging, and above ground biomass on a loam soil in Prince George County, VA. All means are averaged over N rate.

Application Method	Yield	Test Weight	Moisture	Lodging	Biomass
	---bu/A---	---lbs/bu---	------------%	------------	---lbs/A---
No Nitrogen Control	56.0	60.3	11.9	18	7015
Broadcast	62.3	60.1	11.4	42	8373
15 inch Surface Band	70.0	60.8	11.6	31	8335
15 inch Injected Band	53.8	60.2	12.0	14	7256
30 inch Surface Band	62.4	60.0	11.6	28	8222
30 inch Injected Band	62.5	60.1	11.9	17	7865
$LSD_{0.10}$	3.8	0.5	0.2	12	670